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UC-41 – Health and Safety

APPLIED HEALTH PHYSICS AND SAFETY

ANNUAL REPORT FOR 1970

OAK RIDGE NATIONAL LABORATORY
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UNION CARBIDE CORPORATION
for the
U.S. ATOMIC ENERGY COMMISSION

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Abstract: Document contains a summary of environmental data collected during 1970. Data reported includes: water monitoring of the Clinch River and White Oak Creek, drinking water, cow's milk, background measurements, rainwater, airborne particulates, and stack effluents. Other information or data provided are: personnel monitoring, unusual occurrance, and bioassay analysis.

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HEALTH PHYSICS DIVISION

APPLIED HEALTH PHYSICS AND SAFETY ANNUAL REPORT FOR 1970

K. Z. Morgan, Director

W. S. Snyder, Assistant Director

D. M. Davis, Department Head

AUGUST 1971

OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee
operated by
UNION CARBIDE CORPORATION
for the
U. S. ATOMIC ENERGY COMMISSION

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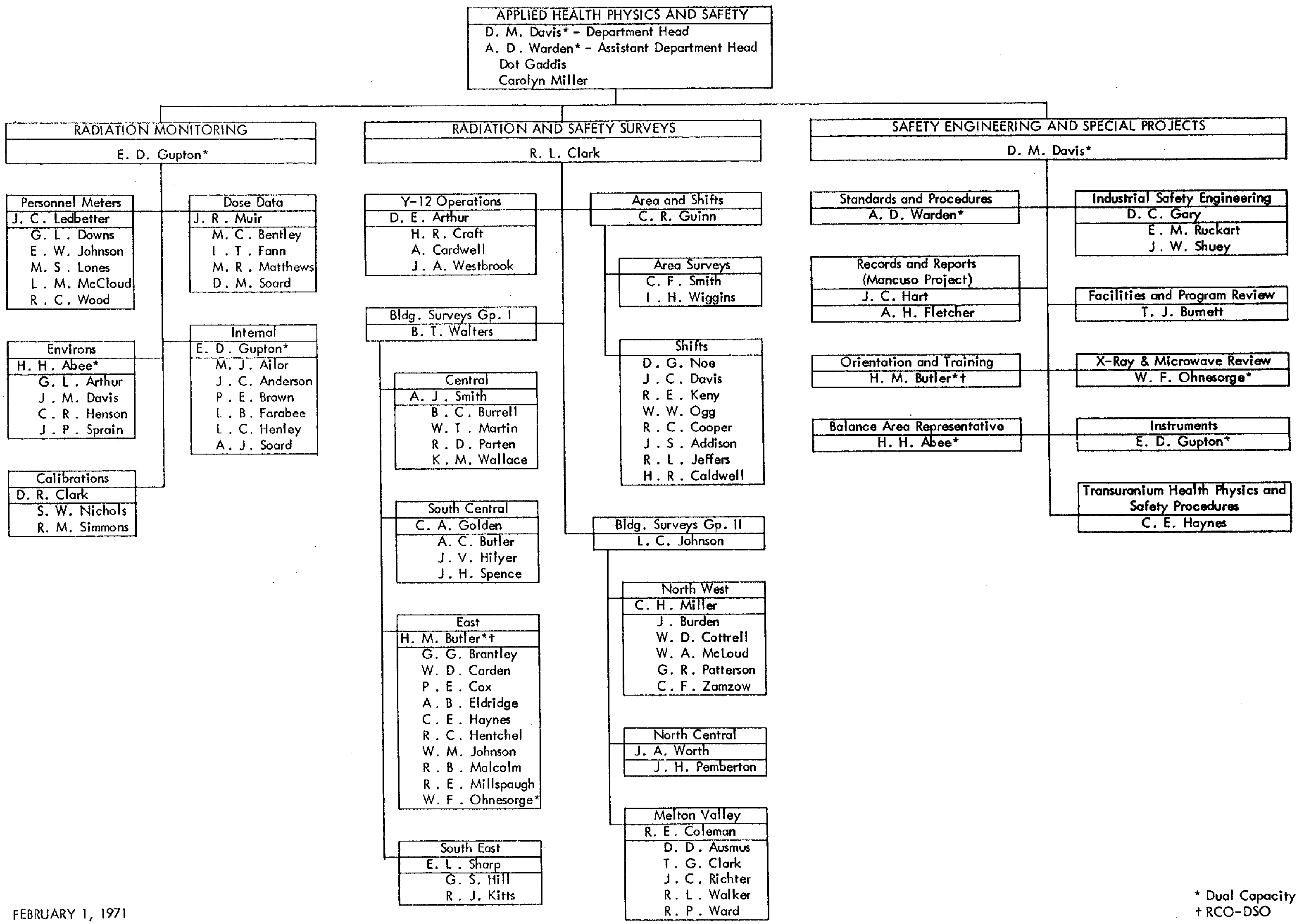
1.0 ORGANIZATION CHART



* Dual Capacity
† RCO-DSO

2.0 SUMMARY

There were no accidental releases of gaseous or liquid waste from the Laboratory which were of a reportable level as defined in AEC Manual Chapter 0524. The concentration of radioactive materials in the environs was well below the maximum levels recommended by the ICRP, FRC, and AEC.

One employee received an internal radiation dose of a level that required a report to the AEC. The highest whole body dose received by an employee was about 4.0 rem or 33 percent of the maximum permissible annual dose. The one case of internal exposure was the deposition of radioactive materials within the lungs of an employee working with plutonium-238.

There were nine unusual occurrences recorded during 1970, which is the lowest number recorded since the present system of reporting unusual occurrences was established in 1960. The second lowest number for any one year was 12, the number reported for 1969. The average number reported for the past five years was 15.6.

The ORNL safety record for 1970 was very good. There was a decrease, from 1969, in the total number of injuries. There has been only one year since the inception of Union Carbide as the contractor at ORNL (1948) in which there were fewer Serious Injuries than the 49 during 1970. There were five Disabling Injuries, a frequency rate of 0.76, which is about 75 percent of the average frequency rate for the past 10 years.

3.0 RADIATION MONITORING

It is the policy of the Oak Ridge National Laboratory to monitor the exposure to personnel and to the environment due to radiation and radioactive materials related to Laboratory operations.

3.1 Personnel Monitoring

All persons who enter Laboratory areas where there is a likelihood of exposure to radiation or radioactive materials are monitored for the kinds of exposure they are likely to sustain. External radiation dosimetry is accomplished mainly by means of film badges, pocket ion chambers, and hand exposure meters. Internal exposure is determined from bio-assays and in vivo counting.

3.1.1 Dose Analysis Summary, 1970

(a) External Exposures - No employee received a whole body radiation dose which exceeded the standards for radiation protection, AEC Chapter 0524. The highest whole body dose received by an employee was about 4.0 rem or 33 percent of the maximum permissible annual dose. The range of doses for persons using ORNL badge-meters is shown in Table 3.1.1.

As of December 31, 1970, no employee had a cumulative whole body dose which exceeded the recommended maximum permissible dose as based on the age proration formula 5(N - 18) (Table 3.1.2). No employee had an average annual exposure rate that exceeded 5 rem per year of employment (Table 3.1.3).

The highest cumulative dose to the skin of the whole body received by an employee during 1970 was about 10 rem or 33 percent of the maximum permissible annual skin dose of 30 rem.

As of December 31, 1970, the highest cumulative dose of whole body radiation received by an employee was approximately 95 rem. This dose was accrued over an employment period of about 27 years and represented an average exposure of about 3.5 rem per year.

The highest cumulative hand exposure recorded during 1970 was about 56 rem or 75 percent of the recommended maximum permissible annual dose to the extremities.

The average of the ten highest whole body doses of ORNL employees for each of the years 1966 through 1970 are shown in Table 3.1.4. The highest individual dose for each of those years is shown, also.

The average annual dose to ORNL employees for the years 1966 through 1970 is the subject of Table 3.1.5. This rather arbitrary quantity is obtained by dividing the sum of all doses for the year by the number of employees involved.

(b) Internal Exposures - One employee sustained lung exposure to plutonium-238 in 1970, estimated to exceed the permissible lung burden (15 nCi). Additional studies are being made to determine the dose commitment from this exposure. There was no other case of internal exposure where the deposition of radioactive materials within the body was estimated to have averaged as much as one-half a maximum permissible body burden for the year.[1]

Three employees continued to have estimated body burdens of transuranic alpha emitters (mainly ^{239}Pu) slightly less than 50 percent of the recommended maximum permissible value.[2] The ICRP recommends, Publication 6, paragraph 86(a), individuals who exceed 50 percent of a maximum permissible body burden be placed on a work assignment where the potential for internal exposure is reduced.

3.1.2 External Dose Techniques

(a) Film Meters - Film meters are issued to all persons who have access to ORNL facilities in which there is a likelihood of radiation exposures for which monitoring is required. Photo-badge-meters are assigned to all ORNL employees, and to certain other persons who are authorized to enter ORNL facilities. Temporary meters may be issued in lieu of photo-badge-meters for short-term use.

NTA (nuclear track) film packets are included in all film meters. The NTA films are processed routinely if the badge-meter is assigned to an individual who normally works where there may be exposure to neutrons; otherwise the films would be processed only in the event of a nuclear accident.

Beta-gamma sensitive films from badge-meters issued to full-time employees are processed routinely each calendar quarter (or more frequently if necessary). Films used in other meters are processed as conditions of use may require. Films from meters issued to visitors are processed if there is a likelihood that a radiation exposure was incurred.

High-level radiation dosimetry components of the badge meters (sulfur, gold, indium, and metaphosphate glass) are for use in the event that doses exceed the capability of the monitoring films.

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[1] NBS Handbook 69 values are the basis for these determinations.

[2] AEC Manual Chapter 0502 requires an evaluation of the radiation exposure status of an employee when monitoring techniques indicate that a body burden equals or exceeds 50 percent of a maximum permissible limit.

(b) Pocket Meters - Pocket meters (indirect reading, ionization chambers) are made available at all principal points of entry to ORNL premises. A pair of pocket meters is carried for the duration of a work shift by persons who work in an area where the potential for an exposure of 20 mR or more exists during the work shift. Pocket meter pairs are processed each day by Health Physics technicians and readings of 20 mR or more are reported daily to supervision. Pocket meters are used for a day-to-day record of integrated exposure.

(c) Hand Exposure Meters - Hand exposure meters are film-loaded finger rings used to measure hand exposure. Hand exposure meters are issued to persons for use during operations where it is likely that the hand dose is such as to exceed 1 rem during the week. They are issued and collected by Radiation and Safety Surveys Section personnel who determine the need for this type of monitoring and arrange for a processing schedule.

(d) Metering Resumé - Shown in Table 3.1.6 are the quantities of personnel metering devices used and processed during 1970. The number of films processed is less than the number issued, because those which are issued for accident dosimetry only are not processed unless there is a likelihood of exposure.

3.1.3 Internal Dose Techniques

(a) Bio-Assays - Urine and fecal samples are analyzed for the purpose of making internal dose determinations. The frequency of sampling and the type of radiochemical analysis performed are based upon each specific radioisotope and the exposure potential. Because of the small quantities of radioactive material in most samples, qualitative analyses are not feasible, and only quantitative analyses for predetermined isotopes are performed routinely.

In most cases bio-assay data require interpretation to determine the dose to the person; computer programs are used for evaluation of extensive data on urinary excretion of ^{239}Pu. An estimate of dose is made for all cases in which it appears that one-fourth of a body burden, average over a calendar year, may be exceeded.

The analyses performed by the Applied Health Physics and Safety Radiochemical Lab during 1970 are summarized in Table 3.1.7.

(b) Whole Body Counter - The Whole Body Counter (an in vivo gamma spectrometer) may be used for determining internally deposited quantities of most radionuclides which emit gamma rays.

During the calendar year 1970 there were 530 whole body or thorax counts of ORNL employees. Of these counts, 510 indicated no detectable activity of significance, and all indicated less than 25 percent of a permissible body burden.

(c) Counting Facility - The Applied Health Physics and Safety counting facility determines radioactivity content of samples submitted by groups within the Department. A summary of analyses is in Table 3.1.8.

3.1.4 Reports

Routine reports of personnel monitoring data are prepared and distributed to Divisional supervision and to Applied Health Physics and Safety staff.

(a) Pocket Meter Data - A report is prepared daily of the names, ORNL division, and readings for pocket meter readings which were 20 mR or greater during the previous 24 hours.

A computer-prepared report, which includes all pocket meter data for the previous week, and summary data for the calendar quarter, is published and distributed weekly.

(b) External Dosimetry Data - A computer-prepared report, which includes data of recorded skin dose and whole body dose for the previous calendar quarter and totals for the current year, is published and distributed quarterly.

(c) Bio-Assay Data - A computer-prepared report, which includes data of sample status and results for the previous week, is published and distributed weekly. A quarterly and an annual report of results are prepared and distributed.

(d) Whole Body Counter Data - Preliminary results of analysis are reported on a card form soon after counting is done.

A computer-prepared report, which includes data collected during the previous calendar quarters of the calendar year, is published and distributed quarterly.

3.1.5 Records

Permanent records of personnel monitoring data are maintained for each person who is assigned an ORNL photo-badge-meter.

3.2 Environs Monitoring

The Health Physics Division monitors for airborne radioactivity in the East Tennessee area by the use of three separate monitoring networks. The local air monitoring (LAM) network consists of 22 stations which are positioned in relation to ORNL operational activities; the perimeter air monitoring (PAM) network consists of nine stations which are located near the perimeter of the AEC-controlled area; and the remote air monitoring (RAM) network consists of eight stations which are located outside the AEC-controlled area at distances of from 12 to 75 miles from ORNL.[3] The monitoring networks provide for the collection of (1) airborne radioactivity by air filtration techniques, (2) radioparticulate fallout material by impingement on gummed paper trays, and (3) rainwater for measurement of fallout occurring as rainout. The filter data are representative of radioparticulate matter which might be considered respirable; the gummed paper data are representative of radioparticulate fallout; and the rainwater data provide information on the soluble and insoluble fractions of the radioactive content of fallout material.

Low-level radioactive liquid wastes originating from ORNL operations are discharged, after preliminary treatment, to White Oak Creek, which is a small tributary of the Clinch River. The radioactive content of White Oak Creek discharge is determined at White Oak Dam which is the last control point along the stream prior to entry of White Oak Creek waters into Clinch River waters. Water samples are collected also at a number of locations along the Clinch River, beginning at a point above the entry of waste into the River via White Oak Creek and ending at Center's Ferry (near Kingston, Tennessee) about 16 miles downstream from the confluence of White Oak Creek and the Clinch River. Water samples are analyzed for gross radioactivity and for specific radionuclides present in detectable quantities. The concentration of each nuclide detected is compared with its respective MPC_w value as specified by AEC Manual Chapter 0524, and the resulting fractions summed to arrive at the percent MPC_w in the Clinch River.

Samples of ORNL potable water are collected daily, composited and stored. At the end of each quarter these composites are analyzed radiochemically for ^{90}Sr content and are assayed for long-lived gamma emitting radionuclides by gamma spectrometry.

Raw milk samples are collected at 12 sampling stations located within a radius of 50 miles from ORNL. Samples are taken on a weekly basis from eight stations which are located outside the AEC-controlled area within a 12-mile radius of ORNL. Samples are collected every five weeks from the four remaining stations, all of which are located outside the 12-mile radius up to distances of about 50 miles. The purpose of the milk sampling program is twofold: first, samples collected in the immediate vicinity of ORNL provide data by which one may evaluate the possible effect of waste releases originating from ORNL operations; second, samples collected remotely to the immediate vicinity of the ORNL area provide background data which are essential in establishing a proper index from which releases of radioactive materials originating from Oak Ridge operations may be evaluated.

Background gamma radiation measurements are made monthly at a number of locations throughout other portions of the East Tennessee area. These measurements are taken with calibrated G-M and scintillation-type detectors at a distance of three feet above the surface of the ground.

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[3]For maps showing location of stations, see ORNL-4423, Applied Health Physics and Safety Annual Report for 1968.

3.2.1 Atmospheric Monitoring

(a) Air Concentrations - The average concentrations of radioactive materials in the atmosphere, as measured by filtration methods provided by the LAM, PAM, and RAM networks during 1970, were as follows:

Network	Concentration (μCi/cc)
LAM	3.3×10^{-13}
PAM	2.1×10^{-13}
RAM	2.3×10^{-13}

The LAM network value of 3.3×10^{-13} μCi/cc is about 0.01 percent of the $MPCU_a$[4] based on occupational exposure of 3×10^{-9} μCi/cc. Both the PAM and RAM network values represent ~0.2 percent of the $MPCU_a$ of 1×10^{-10} μCi/cc applicable to releases to uncontrolled areas. A tabulation of data for each station in each network is given in Table 3.2.1. The weekly values for each network are illustrated in Table 3.2.2.

(b) Fallout (Gummed Paper Technique) - Radioparticulate fallout as measured by the LAM, PAM, and RAM networks did not change significantly from the values observed in 1969. Table 3.2.3 presents a tabulation of the average concentration measured at each station within each network. Table 3.2.4 gives the average concentration for each network by weeks.

(c) Rainout (Gross Analysis of Rainwater) - The average concentration of radioactivity in rainwater collected from the three networks during 1970 was as follows:

Network	Concentration (μCi/cc)
LAM	4.2×10^{-8}
PAM	4.5×10^{-8}
RAM	5.9×10^{-8}

The average concentration in each network was about 1.2 times greater than the values observed during 1969. The average concentration measured at each station within each network is presented in Table 3.2.5. The average concentration for each network for each week is given in Table 3.2.6.

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[4] The $MPCU_a$ is defined as the maximum permissible concentration for an unknown mixture of radioisotopes in air. AEC Manual Chapter 0524, Appendix, Annex 1, gives exposure values applicable to various mixtures of radionuclides and establishes guide lines for deriving the $(MPCU)_a$.

(d) Atmospheric Radioiodine (Charcoal Cartridge Technique) - Atmospheric iodine measured by the perimeter stations averaged 1×10^{-14} μCi/cc during 1970. This average represents 0.01 percent of the maximum permissible inhalation concentration of 1×10^{-10} μCi/cc applicable to ^{131}I released to uncontrolled areas. The maximum concentration observed at any one station for one week was 5.2×10^{-14} μCi/cc. This value was measured at PAM 31, the perimeter station located at Kerr Hollow.

The average radioiodine concentration measured by the local stations was 3×10^{-14} μCi/cc. This concentration is less than 0.01 percent of the maximum permissible inhalation concentration for occupational exposure. The maximum concentration at any one station for one week was 27.6×10^{-14} μCi/cc and occurred at LAM 9 located on the north side of Bethel Valley Road.

Table 3.2.7 presents the ^{131}I weekly average concentration data for both the Plant area (LAM) and the perimeter area (PAM) air monitoring networks.

(e) Milk Analysis - The average concentration of ^{131}I in raw milk samples collected near ORNL (within 12-mile radius) during 1970 ranged between 0.6 and 10.2 pCi/l while the average of samples collected from stations located more remotely from ORNL ranged between 0.2 and 10.1 pCi/l. The upper and lower limit of the average values were arrived at as follows: the minimum detectable limit for ^{131}I in milk is about 10 pCi/l. By setting all samples which measured below the minimum detectable limit at zero, the lower average value is obtained. Alternatively by setting all samples which measured below the minimum detectable limit at the minimum detectable limit (10 pCi/l), the upper average value is obtained. Table 3.2.8 gives the quarterly average and maximum values obtained from samples collected near ORNL and remote from ORNL.

The average concentration of ^{90}Sr in raw milk samples collected near ORNL was 11.4 pCi/l. The average concentration in the samples collected remote from ORNL was 9.3 pCi/l. Table 3.2.9 presents the quarterly average and maximum values obtained from both sampling areas.

The yearly average values for both ^{131}I and ^{90}Sr fall within the limits of FRC Range I daily intake guides, if one assumes an intake of 1 liter of milk per day.

(f) ORNL Stack Releases - The ^{131}I releases from ORNL stacks are summarized in Table 3.2.10.

3.2.2 Water Monitoring

(a) White Oak Lake Waters - A total of 9,473 curies of tritium and 14 beta curies of radioactivity other than tritium were released to the Clinch River during 1970 compared to 12,247 curies of tritium and 13 beta curies of other radionuclides released in 1969 (Table 3.2.11). Yearly discharges of specific radionuclides to the Clinch River, 1965 through 1970, are shown in Table 3.2.12.

The calculated average concentrations of the significant radionuclides in the Clinch River at Clinch River Mile (CRM) 20.8 (the point of entry of White Oak Creek into the River) are presented in Table 3.2.13. The percent MPC_w did not exceed 0.75 percent for any month during 1970 (Table 3.2.14).

(b) Clinch River Water - The measured average concentrations and the percent of MPC_w of radionuclides in the Clinch River at Melton Hill Dam (CRM 23.1), about three miles upstream, and at Center's Ferry (CRM 4.5), about 16 miles downstream from the entry of White Oak Creek, are given in Table 3.2.13.

(c) Potable Water - The average concentrations of ^{90}Sr in potable water at ORNL during 1970 were as follows:

Quarter Number	Concentration ^{90}Sr (μCi/ml)
1	4.5×10^{-10}
2	8.6×10^{-10}
3	4.5×10^{-10}
4	3×10^{-10}
Average for year	5.1×10^{-10}

The average value of 5.1×10^{-10} represents 0.17 percent of the MPC_w for drinking water applicable to individuals in the general population.

(d) Background Measurements - Background measurements were taken at a number of locations (established in 1961) in the East Tennessee area during routine servicing visits to the remote air monitoring stations. Measurements were made at each location on a frequency of once each five weeks. The average background level during 1970 as measured at these stations was 9.8 μR/hr. Average background readings and the location of each station are presented in Table 3.2.15.

Background measurements made monthly with a calibrated G-M monitor at five selected locations adjacent to the ORNL area yielded an average reading of 0.012 mR/hr which is approximately the same level measured in the area prior to Oak Ridge operations. Corresponding measurements made at 53 locations on the ORNL site gave an average background reading of 0.072 mR/hr.

3.2.3 Environmental Monitoring Samples

A listing of environmental monitoring samples processed by type sample, type of analyses, and number of samples is given in Table 3.2.16.

3.3 Health Physics Instrumentation

The Health Physics Division shares with the Instrumentation and Controls Division the responsibility for the selection of electronic radiation monitoring instruments used in the ORNL health physics program. Normally, the Health Physics Division is responsible for determining the need for new instrument types and modifications to existing types, for specifying the health physics requirements and for approval of the design. The Health Physics Division is also responsible for calibrating all instruments used in the health physics program and is allocated the funds for maintenance of these instruments. Maintenance is performed or cross-ordered by the Instrumentation and Controls Division.

Non-electronic personnel monitoring devices are designed, tested, calibrated and maintained by Health Physics Division personnel.

3.3.1 Instrument Inventory

The electronic instruments used in the health physics program are divided, for convenience in servicing and calibrating, into two classes: the first class includes battery-powered portable instruments; the second class includes the stationary instruments that are AC powered. Portable instruments are assigned and issued to the Radiation and Safety Surveys Complexes. Stationary instruments are the property of the ORNL division which has the monitoring responsibility in the area in which the instrument is located. Table 3.3.1 lists portable instruments assigned at the end of 1970; Table 3.3.2 lists stationary instruments at the X-10 site in use at the end of 1970.

There was an increase of nine stationary instruments and a decrease of 45 portable instruments during the year.

During 1970, 900 new pocket meters, 247 new fiber dosimeters (200 mR range) and 19 personal radiation monitors (PRM) were issued by ORNL Stores. The pocket meters issued were replacements for instruments which had been lost or damaged.

Inventory and Service Summaries for health physics instruments are prepared on an IBM 360. These computer-programmed reports enable the Instruments Group to maintain a current inventory on most health physics instrument requirements.

The allocation of stationary health physics monitoring instruments at the X-10 site by division is shown in Table 3.3.3.

3.3.2 Calibration Facility

The Health Physics Division maintains a calibration facility for the calibration and maintenance of portable radiation instruments and personnel metering devices. The facility is equipped with calibration sources, remote control devices, and shop space for the use of Instrumentation and Controls Division maintenance personnel. Health

Physics personnel assign, arrange for maintenance of, calibrate, provide delivery services for, and maintain inventory and servicing data of all portable health physics instruments.

Portable instruments should be serviced (1) whenever repairs are needed, (2) at least once each two months for those which have replacement-type batteries, and (3) at least once each three months for those instruments which have "permanent" (rechargeable) batteries. The number of calibrations of portable instruments for 1970 is shown in Table 3.3.4.

Stationary instruments are calibrated by Calibrations Group personnel or by Radiation and Safety Surveys personnel who use sources which are designed, standardized, and provided by the Calibrations Group.

Table 3.1.1 Dose Data Summary for Laboratory Population Involving Exposure to Whole Body Radiation—1970

Group	Number of Rem Doses in Each Range							Total
	0-1	1-2	2-3	3-4	4-5	5-6	6 up	
ORNL Employees	5152	65	8	2	1	0	0	5228
ORNL-Badged Non-Employees	822	0	0	0	0	0	0	822
TOTAL	5974	65	8	2	1	0	0	6050

Table 3.1.2 Average Rem Per Year Since Age 18—1970

	Number of Doses in Each Range				Total
	0-2.5	2.5-5.0	5.0-7.5	7.5 up	
ORNL Employees	5222	6	0	0	5228

Table 3.1.3 Average Rem Per Year of Employment at ORNL—1970

	Number of Doses in Each Range				Total
	0-2.5	2.5-5.0	5.0-7.5	7.5 up	
ORNL Employees	5207	21	0	0	5228

Table 3.1.4 Average of the Ten Highest Whole Body Doses and the Highest Individual Dose by Year

Year	Average of the Ten Highest Doses (Rem)	The Highest Dose (Rem)
1966	3.81	4.85
1967	4.01	5.10
1968	4.11	4.71
1969	2.84	3.79
1970	2.79	4.04

Table 3.1.5 Average Annual Whole Body Dose to the Average ORNL Employee

Year	Average Dose (Rem)
1966	0.126
1967	0.142
1968	0.114
1969	0.088
1970	0.074

Table 3.1.6 Personnel Meter Services

	1968	1969	1970
A. Pocket Meter Usage			
1. Number of Pairs Used			
ORNL	143,572	128,024	95,524
CPFF	5,564	7,228	12,844
Total	149,136	135,252	108,368
2. Average Number of Users per Quarter			
ORNL	1,273	1,149	998
CPFF	94	120	143
Total	1,367	1,269	1,141
B. Film Usage			
1. Films Used in Photo-Badge-Meters			
Beta-Gamma	22,100	20,930	19,710
NTA	10,940	10,360	9,760
2. Films Used in Temporary Meters			
Beta-Gamma	8,850	8,440	5,800
NTA	2,860	2,730	1,880
C. Films Processed for Monitoring Data			
1. Beta-Gamma	22,720	21,800	20,700
2. NTA	1,190	1,400	1,230
3. Hand Meter	1,110	1,100	970

Table 3.1.7 Radiochemical Lab Analyses—1970

Radionuclide	Urine	Feces	Milk	Other	Controls
Plutonium, Alpha	979	19		12	250
Trans Plutonium, Alpha	587	32			250
Uranium, Alpha	338			12	25
Strontium, Beta	806		436		75
Cesium-137	198				
Tritium	258				25
Iodine-131			436		52
Other	99	8		104	
TOTALS	3265	59	872	128	677

Table 3.1.8 Counting Facility Analyses—1970

Types of Samples	Number of Samples			Unit Total
	Alpha	Beta	Gamma	
Facility Monitoring				
Smears	56,363	57,582		113,945
Air Filters	21,491	21,491		42,982
Environs Monitoring				
Air Filters	1,685	1,685		3,370
Fallout		1,490		1,490
Rain Water		1,366		1,366
Surface Water	105	627		732
Milk			441	441

Table 3.2.1 Concentration of Radioactive Materials in Air—1970
(Filter Paper Data—Weekly Average)

Station Number	Location	Long-Lived Activity 10^{-13} μCi/cc	Particles[a] Per 1000 ft^3
	Laboratory Area		
HP-1	S 3587	2.6	0
HP-2	NE 3025	3.5	0
HP-3	SW 1000	3.1	0
HP-4	W Settling Basin	3.3	0
HP-5	E 2506	3.6	0
HP-6	SW 3027	3.5	0
HP-7	W 7001	3.5	0
HP-8	Rock Quarry	3.1	0
HP-9	N Bethel Valley Rd.	3.3	0
HP-10	W 2075	3.0	0
HP-16	E 4500	3.5	0
HP-20	HFIR	3.8	0
Average		3.3	0
	Perimeter Area		
HP-31	Kerr Hollow Gate	2.0	0
HP-32	Midway Gate	2.4	0
HP-33	Gallaher Gate	1.8	0
HP-34	White Oak Dam	2.0	0
HP-35	Blair Gate	2.1	0
HP-36	Turnpike Gate	2.5	0
HP-37	Hickory Creek Bend	1.8	0
HP-38	E EGCR	2.2	0
HP-39	Townsite	2.4	0
Average		2.1	0
	Remote Area		
HP-51	Norris Dam	2.1	0
HP-52	Loudoun Dam	2.4	0
HP-53	Douglas Dam	2.3	0
HP-54	Cherokee Dam	2.3	0
HP-55	Watts Bar Dam	2.5	0
HP-56	Great Falls Dam	2.1	0
HP-57	Dale Hollow Dam	2.0	0
HP-58	Knoxville	2.5	0
Average		2.3	0

[a]Detection limit - 10^4 d/24 hrs per particle by autoradiographic technique.

Table 3.2.2 Concentration of Radioactive Materials in Air as Determined from Filter Paper Data—1970 (System Average - by Weeks)

Week Number	Units of 10^{-13} μCi/cc			Week Number	Units of 10^{-13} μCi/cc		
	LAM's	PAM's	RAM's		LAM's	PAM's	RAM's
1	0.6	0.29	0.38	29	7.0	4.0	4.9
2	0.8	0.32	0.40	30	1.7	0.99	1.2
3	1.5	0.56	0.58	31	2.6	1.7	2.1
4	0.8	0.54	0.48	32	4.3	3.0	3.3
5	0.8	0.56	0.67	33	2.9	2.1	2.0
6	1.4	0.74	0.70	34	1.6	1.3	1.2
7	1.2	0.85	0.97	35	6.3	3.0	3.2
8	2.2	1.4	1.3	36	1.6	1.3	1.2
9	2.2	1.8	1.8	37	2.9	1.9	1.8
10	3.3	2.0	2.2	38	1.3	0.72	1.1
11	2.6	1.8	2.0	39	0.7	0.63	0.46
12	2.7	1.6	1.7	40	1.8	1.4	1.2
13	3.1	1.8	1.8	41	1.5	0.84	1.3
14	2.4	1.7	2.0	42	1.7	1.3	1.2
15	5.2	2.6	3.2	43	2.2	1.1	1.2
16	2.3	1.9	1.7	44	1.8	0.88	1.1
17	5.9	3.2	3.9	45	1.7	1.3	1.1
18	4.1	3.2	3.0	46	1.3	1.3	1.2
19	7.9	5.2	5.5	47	1.6	1.3	1.1
20	7.9	5.4	4.9	48	1.5	0.97	0.91
21	7.5	5.6	6.3	49	1.4	1.0	1.1
22	7.6	4.7	4.7	50	1.4	0.88	0.69
23	4.6	2.8	3.1	51	1.6	0.77	1.1
24	5.8	4.4	3.7	52	6.1	4.0	4.2
25	5.6	3.7	4.7				
26	11.4	6.5	7.2				
27	6.0	2.8	4.3				
28	6.9	4.8	5.0	Average	3.3	2.1	2.3

Table 3.2.3 Radioparticulate Fallout—1970
(Gummed Paper Data—Weekly Average)

Station Number	Location	Long-Lived Activity 10^{-4} $\mu Ci/ft^2$	Total[a] Particles Per Sq. Ft.
	Laboratory Area		
HP-1	S 3587	0.67	0.13
HP-2	NE 3025	0.63	0.08
HP-3	SW 1000	0.50	0.02
HP-4	W Settling Basin	0.57	0.10
HP-5	E 2506	0.60	0.19
HP-6	SW 3027	1.28	1.00
HP-7	W 7001	0.51	0.02
HP-8	Rock Quarry	0.52	0.02
HP-9	N Bethel Valley Rd.	0.46	0.02
HP-10	W 2075	0.86	0.21
HP-16	E 4500	0.53	0.08
HP-20	HFIR	0.45	0.00
Average		0.63	0.15
	Perimeter Area		
HP-31	Kerr Hollow Gate	0.56	0.02
HP-32	Midway Gate	0.66	0.04
HP-33	Gallaher Gate	0.48	0.02
HP-34	White Oak Dam	0.49	0.00
HP-35	Blair Gate	0.50	0.04
HP-36	Turnpike Gate	0.53	0.00
HP-37	Hickory Creek Bend	0.41	0.00
HP-38	E EGCR	0.45	0.00
HP-39	Townsite	0.61	0.02
Average		0.52	0.02
	Remote Area		
HP-51	Norris Dam	0.46	0.00
HP-52	Loudoun Dam	0.35	0.00
HP-53	Douglas Dam	0.41	0.00
HP-54	Cherokee Dam	0.40	0.04
HP-55	Watts Bar Dam	0.44	0.00
HP-56	Great Falls Dam	0.36	0.00
HP-57	Dale Hollow Dam	0.46	0.00
HP-58	Knoxville	0.51	0.00
Average		0.42	< 0.01

[a]Detection limit - 10^4 d/24 hr per particle by autoradiographic technique.

Table 3.2.4 Radioparticulate Fallout Measurements[a] as Determined by Autoradiographic Techniques—1970 (Gummed Paper Data - System Average by Weeks)

Week Number	Particles/ft^2			Week Number	Particles/ft^2		
	LAM's	PAM's	RAM's		LAM's	PAM's	RAM's
1	0.08	0.22		29	0.25		
2				30			
3	0.08			31			
4	0.17			32	0.08		
5				33			
6				34			
7	0.25			35	0.25		0.13
8	0.04			36		0.11	
9	0.08			37	0.58		
10	0.08	0.11		38			
11		0.11		39			
12	0.25			40	0.33		
13	0.33	0.11		41			
14	0.25	0.11		42	0.08		
15	0.67			43			
16	0.25			44			
17				45	0.17		
18	0.17			46	0.08		
19	0.67			47	1.25		
20	0.08		0.13	48			
21	0.33			49	0.17		
22				50	0.17		
23	0.25			51			
24				52			
25							
26	0.17						
27	0.25						
28	0.17			Average	0.15	0.02	< 0.01

[a]Detection limit - 10^4 d/24 hr per particle.

Blank entries are zero.

Table 3.2.5 Concentration of Radioactive Materials in Rainwater—1970
(Weekly Average by Stations)

Station Number	Location	Activity in Collected Rainwater, µCi/ml
	Laboratory Area	
HP-7	West 7001	4.2×10^{-8}
	Perimeter Area	
HP-31	Kerr Hollow Gate	4.4×10^{-8}
HP-32	Midway Gate	3.7
HP-33	Gallaher Gate	6.1
HP-34	White Oak Dam	5.3
HP-35	Blair Gate	3.9
HP-36	Turnpike Gate	4.3
HP-37	Hickory Creek Bend	3.2
HP-38	E EGCR	5.6
HP-39	Townsite	3.9
Average		4.5×10^{-8}
	Remote Area	
HP-51	Norris Dam	6.4×10^{-8}
HP-52	Loudoun Dam	6.5
HP-53	Douglas Dam	4.9
HP-54	Cherokee Dam	6.9
HP-55	Watts Bar Dam	4.8
HP-56	Great Falls Dam	6.9
HP-57	Dale Hollow Dam	5.3
HP-58	Knoxville	5.2
Average		5.9×10^{-8}

Table 3.2.6 Weekly Average Concentration of Radioactivity in Rainwater—1970 (Units of 10^{-8} μCi/ml)

Week Number	LAM's	PAM's	RAM's	Week Number	LAM's	PAM's	RAM's
1	5.5	3.3	1.4	29	5.0	*	6.1
2	*	*	*	30	2.3	2.8	4.4
3	0.0	0.6	1.7	31	16.3	6.1	10.0
4	3.1	3.3	3.6	32	2.6	1.9	2.7
5	0.4	6.9	8.4	33	11.4	4.3	4.2
6	2.4	4.7	4.6	34	4.8	2.5	3.4
7	6.4	6.5	8.0	35	*	*	*
8	1.7	6.9	8.4	36	2.0	0.70	1.7
9	1.7	6.3	8.5	37	*	4.4	2.7
10	5.1	5.4	6.7	38	10.8	2.3	1.6
11	4.1	6.9	12.4	39	0.70	1.4	1.6
12	5.6	6.0	7.9	40	*	*	*
13	6.8	9.9	12.5	41	1.3	1.6	1.7
14	4.1	5.6	6.3	42	0.6	0.70	6.7
15	*	12.6	9.2	43	0.80	*	1.9
16	4.5	6.5	5.9	44	2.4	1.6	2.0
17	10.4	9.0	9.8	45	*	3.9	6.8
18	17.2	13.3	20.1	46	5.0	7.2	6.5
19	*	*	*	47	0.90	4.5	3.4
20	13.4	10.8	9.4	48	*	*	*
21	*	*	*	49	*	*	*
22	*	8.7	9.0	50	1.3	1.3	1.2
23	6.1	6.8	7.2	51	2.9	3.3	3.4
24	4.7	5.2	7.8	52	1.4	2.6	2.8
25	6.3	5.9	9.3				
26	*	*	10.8				
27	*	*	15.5				
28	6.4	7.6	4.5	Average	4.2	4.5	5.9

*No rainfall.

Table 3.2.7 Weekly Average Concentration of ^{131}I in Air—1970
(Units of 10^{-14} μCi/cc)

Week Number	LAM's	PAM's	Week Number	LAM's	PAM's
1	16.3	2.4	29	2.9	0.8
2	3.6	0.9	30	3.9	1.0
3	1.9	0.8	31	2.6	1.5
4	2.4	0.7	32	2.0	1.1
5	2.0	0.9	33	4.0	1.1
6	1.8	0.7	34	3.7	1.0
7	1.6	0.9	35	3.5	0.8
8	2.3	0.7	36	3.4	0.9
9	2.3	0.6	37	2.4	0.7
10	2.6	1.1	38	2.4	0.8
11	5.0	1.4	39	2.5	0.7
12	2.5	0.8	40	3.8	0.7
13	2.5	1.3	41	2.9	0.7
14	3.1	0.7	42	1.9	0.6
15	2.2	0.9	43	2.5	0.8
16	2.5	0.8	44	1.3	0.6
17	1.8	0.6	45	3.4	0.9
18	2.2	1.3	46	2.4	0.6
19	2.9	1.0	47	1.5	0.8
20	4.5	1.0	48	2.1	0.7
21	6.1	0.6	49	3.3	1.3
22	3.2	0.7	50	1.6	0.6
23	2.2	0.7	51	1.4	0.7
24	2.2	0.5	52	7.4	4.7
25	3.0	0.9			
26	2.8	0.8			
27	2.4	0.9			
28	1.9	0.9	Average	3.0	1.0

Table 3.2.8 Concentration of ^{131}I in Raw Milk—1970
(Units of pCi/l)

Quarter	Near ORNL		Remote from ORNL	
	Average*	Maximum	Average*	Maximum
1	1 - 10.4	27	0 - 10	10
2	0 - 10.0	10	0 - 10	10
3	0.2 - 13.0	13	0 - 10	10
4	1.4 - 10.4	21	0.9 - 10.5	11.4
Annual	0.6 - 10.2		0.2 - 10.1	

*See text, paragraph 3.2.1(e).

Table 3.2.9 Concentration of ^{90}Sr in Raw Milk—1970
(Units of pCi/l)

Quarter	Near ORNL		Remote from ORNL	
	Average	Maximum	Average	Maximum
1	10	39	8.1	15
2	12	26	11	17
3	12	25	9.2	13
4	10	21	9.6	10
Annual	11.4		9.3	

Table 3.2.10 Discharge of ^{131}I from ORNL Stacks—1970*

Stack Number	Curies	
	Total for Year	Monthly Average
3026	0.01	< 0.001
3039	1.21	0.101
3020	0.04	0.003
7512	0.02	0.002
7911	0.15	0.013
Total	1.43	0.119

*Data furnished by Operations Division.

Table 3.2.11 Liquid Waste Discharged to Clinch River—1970

	Curies	
	Total for Year	Monthly Average
Beta Activity other than Tritium	14	1.13
Tritium	9,473	789
Transuranic Alpha Emitters	0.4	0.033

Table 3.2.12 Yearly Discharges of Radionuclides to Clinch River
(Curies)

Year	^{137}Cs	^{106}Ru	^{90}Sr	TRE*(-Ce)	^{144}Ce	^{95}Zr	^{95}Nb	^{131}I	^{60}Co	^{3}H
1965	2.1	69	3.4	5.9	0.1	0.33	0.33	0.20	12	
1966	1.6	29	3.0	4.9	0.1	0.67	0.67	0.24	7	3093
1967	2.7	17	5.1	8.5	0.2	0.49	0.49	0.91	3	13273
1968	1.1	5	2.8	4.4	0.03	0.27	0.27	0.31	1	9685
1969	1.4	1.7	3.1	4.6	0.02	0.18	0.18	0.54	1	12247
1970	2.0	1.2	3.9	4.7	0.06	0.02	0.02	0.32	1	9473

*Tri-Valent Rare Earths.

Table 3.2.13 Radioactivity in Clinch River—1970

Location	Concentration of Radionuclides of Primary Concern Units of 10^{-8} μCi/ml							% MPC_w
	^{90}Sr	^{144}Ce	^{137}Cs	$^{103-106}Ru$	^{60}Co	^{95}Zr-^{95}Nb	^{3}H	
Melton Dam[a]	0.05	0.02	0.04	0.04	0.03	0.02	140	0.22
Clinch River at White Oak Creek[b]	0.06	< 0.01	0.02	0.02	0.01	< 0.01	136	0.27
Center's Ferry[a]	0.11	0.03	0.19	0.05	0.10	0.02	220	0.47

[a]Measured values.

[b]Values given for this location are calculated values based on the concentrations of wastes released from White Oak Dam and the dilution afforded by the Clinch River; they do not include radioactive materials (e.g., fallout) that may enter the river upstream from CRM 20.8.

Table 3.2.14 Calculated Percent MPC_w of ORNL Radioactivity Releases in Clinch River Water Below the Mouth of White Oak Creek—1970

Month	% MPC_w
January	0.42
February	0.30
March	0.38
April	0.73
May	0.23
June	0.20
July	0.14
August	0.22
September	0.13
October	0.24
November	0.55
December	0.33
Average	0.27

Table 3.2.15 Background Radiation in East Tennessee Area—1970

Stations	μR/hr
Great Falls	9.6
Dale Hollow	9.9
Crossville	9.6
Watts Bar	10.2
Rockwood	9.2
Wartburg	9.1
Kingston	9.3
Oliver Springs	10.5
Lenoir City	8.8
Clinton	9.3
Norris	8.7
Powell	12.7
Halls Cross Roads	10.6
Strawberry Plains	10.2
Cherokee	9.4
Average	9.8

Table 3.2.16 Environmental Monitoring Samples—1970

Sample Type	Type of Analyses	Number Samples
Monitoring network filters	Gross beta, autoradiogram	1717
Gummed paper fallout trays	Gross beta, autoradiogram	1497
Rain water	Gross beta	810
White Oak Dam effluent	Gross beta, radiochemical, gamma spectrometry	534
Clinch River water	Gross beta, radiochemical, gamma spectrometry	12
Raw milk	Radiochemical	441
Potable water	Radiochemical, gamma spectrometry	4
Silt composites	Radiochemical, gamma spectrometry	37

Table 3.3.1 Portable Instrument Inventory—1970

Instrument Type	Instruments Added 1970	Instruments Retired 1970	In Service Jan. 1, 1971
G-M Survey Meter	30	37	499
Cutie Pie	3	26	441
Alpha Survey Meter	6	13	253
Neutron Survey Meter	6	1	106
Miscellaneous	0	13	27
TOTAL	45	90	1328

Table 3.3.2 Inventory of Facility Radiation Monitoring Instruments for the Year—1970

Instrument Type	Installed During 1970	Retired During 1970	Total Jan. 1, 1971
Air Monitor, Alpha	0	1	99
Air Monitor, Beta	0	0	178
Hand-Foot Monitor	0	1	33
Lab Monitor, Alpha	14	2	184
Lab Monitor, Beta	2	0	212
Monitron	3	2	222
Other	1	5	118
TOTAL	20	11	1046

Table 3.3.3 Health Physics Facility Monitoring Instruments
Divisional Allocation at X-10 Site—1970

ORNL Division	α Air Monitor	β Air Monitor	α Lab Monitor	β Lab Monitor	Monitron	Other	Total
Analytical Chemistry	6	14	16	19	15	6	76
Chemical Technology	49	47	59	31	38	34	258
Chemistry	9	9	20	25	20	8	91
Metals and Ceramics	11	7	13	5	5	8	49
Isotopes	15	29	24	41	53	22	184
Operations	2	50	5	31	57	19	164
All Others	7	22	47	60	34	54	224
TOTAL	99	178	184	212	222	151	1046

Table 3.3.4 Calibrations Resumé—1970

		1969	1970
A.	Portable Instruments Calibrated		
	1. Beta-Gamma	3,778	3,228
	2. Neutron	350	327
	3. Alpha	943	797
	4. Pocket Chambers and Dosimeters	1,833	1,401
B.	Films Calibrated	2,360	1,402

4.0 RADIATION AND SAFETY SURVEYS

It is the policy of the Oak Ridge National Laboratory that radiation and safety surveys shall be performed at a frequency and to the extent necessary to assure safe working conditions.

4.1 Laboratory Operations Monitoring

During 1970 Radiation and Safety Surveys personnel assisted the operating groups in keeping the contamination, air concentration and personnel exposure levels well below the established maximum permissible limits. Through seminars, safety meetings and informal discussions with supervision, they assisted in reducing or eliminating a number of problems associated with radiation protection at the Laboratory. The following is a brief description of some of the problems and methods of solution.

4.1.1. Chemical Technology Division Operations and Health Physics Assistance in Support of the Light Water Breeder Reactor Program – ORNL has entered into a contract with Bettis Atomic Power Laboratory to prepare ceramic grade $^{233}UO_2$ fuel for the LWBR. Additional facilities were required in Building 3019 to store oxides and solutions of ^{233}U for this program. Nine additional oxide storage wells 15' deep and 4" in diameter were drilled from the penthouse into the shielding wall between Pilot Plant Cells 2 and 3. Five additional solution storage tanks were installed in the center pipe tunnel each with a capacity of 100 kg ^{233}U at 250 g/liter. Due to prior decontamination and fixation of alpha contamination much of the construction work by the CPFF contractor was possible using minimal protective clothing.

Approximately 232 kg of ^{233}U (as oxides in sealed cans) were transferred to the new and existing storage wells from shipping containers received from Savannah River Laboratory and Nuclear Fuel Services, Inc. The use of a long handled, vacuum, transfer tool eliminated direct handling of the cans and minimized exposure to personnel.

Six hundred thirty-nine bottles containing a total of 588 kg ^{233}U in solution were received from Atlantic Richfield Company, Hanford, Washington. The bottles were transferred (one at a time) from their shipping containers to a gloved box in Room 303-A where the solution was diluted and piped to the pipe tunnel storage tanks (packed with borosilicate-glass raschig rings). These transfers were completed with no one exceeding a weekly dose equivalent of 100 mrem. Alpha containment problems were encountered in unloading the first two shipments as some ^{233}U solution had spilled from some of the primary polyethylene bottles into the secondary steel cylinders of the shipping drums. With careful alpha monitoring and use of protective apparel the transfers were completed with only minor spread of contamination. Containment was upgraded on later shipments and only minor contamination control problems were encountered.

The old Thorex Pilot Plant dissolver (S-1 tank) was removed from Cell 5 and replaced with an improved design dissolver. The new dissolver will be used for "scrap oxides" (containing ^{233}U and ^{232}Th) as returned from Bettis Atomic Power Laboratory for reprocessing. Though S-1 tank was alpha contaminated in excess of 5×10^5 d/m/100 cm^2, the transfer to the burial ground was completed with no significant spread of contamination outside the cell.

4.1.2 Health Physics Assistance Provided During the Transfer of the Interim Alpha Facility, Building 3019, to Building 4508, Room 265 - Gloved boxes and equipment for conversion of purified ^{233}U solutions to a ceramic grade oxide for shipment to Bettis Atomic Power Laboratory are to be located in the Interim Alpha Facility (Room 502, Building 3019). This required relocation of the Metals and Ceramics Division's plutonium containment gloved boxes from the Interim Alpha Facility to a new laboratory constructed in Room 265, Building 4508. Health Physics personnel at Buildings 3019 and 4508 assisted in planning for and provided continuous monitoring of all phases of the transfer. All unsecured equipment was bagged from the gloved boxes for transfer in steel drums or cans. Box interiors were cleaned with wet wipes to remove loose gross alpha contamination. Gloved boxes, flanged together in lines, were separated using a sealed bag technique. Plastic bags and polyvinyl tape provided extra containment over bag and gloved ports. Box windows were covered with polyvinyl tape and protected against breakage by plywood. Upon removal from the off-gas system, each box was sealed in a heavy gauge plastic cover and transported to Building 4508 within an enclosed van. Three boxes, which were sent to the burial ground, were additionally sealed in plywood crates. All twenty-two Pu-contaminated gloved boxes were relocated with no significant release of contamination.

4.1.3 Installation of Charcoal Filters in the HRLAL (Building 2026) Cell Ventilation Systems - Charcoal filters were installed in the HRLAL cell exhaust filter pits to reduce radioiodine release to the atmosphere during processing of short-cooled fission product samples. Only one of the three parallel filter pits was modified at a time to minimize effects on hood and cell ventilation. After removal of the contaminated HEPA filters the pits were decontaminated and the cleaned sections were isolated from the contaminated pre-filter sections by use of plywood partitions. Thus, much of the work by the CPFF contractor was possible without respiratory protection and with minimum protective clothing. The job was completed with no significant spread of contamination and with dose equivalents to personnel well within the permissible limits.

4.1.4 Installation of ^{90}Sr-^{90}Y Irradiator in Building 2001 - Health Physics assisted in the design of and monitored the installation of a beta irradiator in Room 306, Building 2001. The irradiator is to be used for ecological studies. A special tool designed to shield personnel from the intense beta radiation was used to transfer the 1.2 Ci and 12 Ci sources into the shielded irradiator. The exposure rate outside the irradiator shield is $<$ 2 mR/hr. The irradiator is designed with interlocks which preclude personnel access to the irradiation chamber except when the sources are shielded.

4.1.5 Dismantling of Cell 19, Room 17, Building 4505, for Removal from Building - Health Physics assistance was provided for the planning and monitoring of the dismantling of the "hot" Cell 19 in Lab. 17 of Building 4505. Working background levels within the cell averaged 600 mrem/hr and transferable contamination levels reached 5×10^4 alpha d/m and 20 mrem/hr beta-gamma. Bag-out procedures were used to remove contaminated items from the cell and the cell surfaces were hosed down and scrubbed with decontaminants. The background radiation level was reduced to 10 mR/hr. Contamination clothing and masks were worn as were other appropriate protective equipment during the plasma arc cutting of the cell. All dismantled items were wrapped in heavy plastic and removed for disposal. There was no spread of contamination and no significant personnel exposures.

4.1.6 Annual Survey of X-Ray Equipment - All operating X-ray units in use at ORNL were reviewed during the year. The review focused on the following items: (1) clear and adequate identification of X-ray machine and work areas in which the machines are located; (2) radiation leakage around the machine; (3) operation and integrity of interlocks and other safety devices; (4) person primarily responsible for X-ray machine and designated operators for same; (5) changes in equipment related to experiments since the last review; (6) blueprints and/or diagrams of safety equipment; and (7) written operating procedures. Only a few minor deficiencies were noted on items 1 through 5, and much progress has been made on items 6 and 7.

4.1.7 Applied Health Physics and Safety Activities in the Transuranium Research Laboratory during 1970 - The TRL staff of five personnel engaged in Applied Health Physics and Safety activities continued to collaborate with TRL researchers, working directly with them in planning and conducting specific experiments with transuranium isotopes. Experimental assistance was provided in the same general areas outlined in Applied Health Physics and Safety Annual Report for 1969 with increased emphasis on the preparation of special transuranium targets for cyclotron bombardment and assistance at the ORIC.

In addition, members of the staff assisted in a successful dismantling, decontamination, repair, and reassembly operation on the TRL electromagnetic separator.

With the assistance of a radiological health fellow assigned to the TRL for his ORNL experimental training, a series of measurements were made with a 700 μg ^{252}Cf source in air and with albedo from a typical laboratory wall to determine the DE buildup and the relative response of various neutron instruments. Instruments checked included the ORNL fast neutron meter, high range fast neutron meter, moderated thermal neutron meter, the "Bean" (a rem meter under development at the TRL) and the "Hankins" 9" rem meter. These data have been made available to various personnel planning work with ^{252}Cf.

Members of the staff continued to be responsible for the inspection, testing and operation of all stages of the building containment and air-cleaning system and the primary containment gloved box system.

One member of the staff participated in the activities of the Ad Hoc Committee on Transuranium Bearing Solid Waste.

Interaction with personnel at other installations included consultation with research and operating personnel regarding transuranium element handling problems at the AEC New Brunswick Laboratory, The Atomic Energy Research Establishment, Harwell, England, University of Liege, Belgium, The European Transuranium Institute, Karlsruhe, Germany, Centre D'Etudes Nucleaires, de Fontenay-aux-Roses and Institute de Physique Nucleaire, Paris, France.

4.1.8 Health Physics Assistance during Restoration of Cell 12, Building 3517 - Since the beginning of the SNAP program several years ago, ^{90}Sr pellets have been pressed in Cell 12 from strontium titanate or strontium silicate. Early in 1970 it became necessary to take the following steps: (1) to remove an air hoist and the existing electrical outlets; (2) to install new type air lock doors into the adjoining cells; (3) to replace the hydraulic lines, electrical outlets, and lights; and (4) to modify the cell ventilation and install a coolant fan and coil.

Decontamination from the top of the cell got underway on March 17, 1970. A ten-inch plug was removed from the top of the cell and the radiation readings were as follows: inside the cell—< 100 R/hr; directly over opening—10 R/hr at 6"; and around the opening—500 to 1000 mR/hr. A modified 10' x 10' Sears metal storage building was placed over the cell to prevent the spread of contamination throughout the bay area, and a high pressure spray inserted through the 10-inch opening. Spraying and scrubbing with Turco, Oxalic Acid, Ajax, and hot water gradually reduced the readings, but only a very limited working time was achieved.

A box was made of two-inch plywood with removable panels in front—one of which was lucite made up with glove ports for use with lead gloves while operating the spray. With the plywood box sitting on the floor of the cell the reading through the bottom was 600 mR/hr and at eye level 2,000 mR/hr. Working from the box, wearing coveralls, rubber gloves and an airline suit, under constant surveillance, equipped with film rings and special badges, Plant and Equipment personnel completed the job. They had spent a total of 7-1/2 hours in the cell with no single total body exposure > 300 mR/wk.

4.1.9 Renovation of Cell II, Building 3003 - Health Physics consultation and on-the-job surveillance were provided in Cell II of Building 3003 as preparations were made for the installation of a 2 MeV Van de Graaff Proton Accelerator.

This work (using ORNL personnel) involved the removal of a highly contaminated fan and existing duct work which were part of the OGR exhaust cooling system along with removal of wide spread residual contamination with levels up to 2 R/hr. The work was completed with no spread of contamination outside established control zones and with exposures to personnel well within permissible limits.

After the above work was completed, Rust Engineering personnel were able to start the final preparations for the facility without any work restrictions insofar as radioactive materials were concerned.

4.1.10 Surveys Conducted to Test Shielding Integrity of Cells B and G, Building 7930 (TURF) – Radiation and Safety Surveys personnel assisted building operating groups in researching the effects of a 25,000 Ci ^{60}Co source in B cell on neutron detectors. Survey of the exterior surface of the cell during this period revealed some weak areas in cell structure which are to be reshielded.

A complete neutron and gamma survey was made of G cell using a 2 mg ^{252}Cf source located inside the cell. No significant readings above background were detected outside the cell.

Also, Radiation and Safety Surveys personnel assisted in the removal and transfer of ^{252}Cf samples, items of equipment, and radioactive waste from G cell. A film survey was made of G cell to determine dose rates at various places in the cell in conjunction with planning procedures for waste removal.

During this period, up to 90 mg of ^{252}Cf were handled in G cell without incident or undue exposure to personnel. Approval has been given for handling up to 200 mg of ^{252}Cf in the cell in the future.

4.1.11 Installation of Pneumatic Transfer Tube Between Cell 1 of TRU (Building 7920) and G Cell of TURF (Building 7930) – A pneumatic transfer tube was constructed between Cell 1 of TRU and G cell of TURF for the purpose of transferring mg quantities of ^{252}Cf between the two buildings. "Rabbits" containing up to 90 mg of ^{252}Cf have been sent through the tube without incident. Some of the tube is exposed at both buildings and is well marked and monitored. The "rabbit" travels at a speed that will give only a "flash" reading. Radiation survey measurements have indicated that exposure to personnel will not be significant.

4.1.12 Decontamination Facility for Product Sources at TRU, Building 7920 – Product sources of californium in mg quantities can be processed in the Target Decontamination Facility (TDF) at Building 7920 (TRU). The TDF is a portable water-shielded manipulator cell which is used for transferring ^{252}Cf sources to and from cell G in TURF (Building 7930) as well as decontamination of the product sources prior to shipment. The TDF is equipped with various services and ultrasonic cleaning techniques for the decontamination process.

The portability of the TDF allows the loading of product sources directly into a carrier by use of a winch inside the TDF. The operation can be accomplished without significant radiation exposure to the operating personnel.

The containment for the TDF ties in to the regular cell off-gas at TRU. A shielded port allows loading and unloading of various operating materials and tools through a double door system which maintains containment and aids in preventing the spread of contamination. To date mg quantities of ^{252}Cf product sources have been processed and the operating personnel exposure has been well below permissible levels.

4.1.13 Radiation Surveys Made Off Area - Health Physics, on authorized requests, also furnished survey coverage for a number of off-area projects. Following is a brief description of some of the items covered.

4.1.13(a) Health Physics Coverage of the Radio-Isotopic Sand Tracer Project - In a continuation of a project instituted during 1967 a representative of the Radiation and Safety Surveys Section again acted as project health physicist at the Radio-Isotopic Sand Tracer Tests, conducted by the Technical Services Group of the Isotopes Division for the U. S. Corps of Engineers. Three tests were conducted, one at Ocean Side, California, and two at Point Mugu, California. The tests involved placing radioactive sand tagged with $^{198-199}Au$ off shore and tracing its movement along the ocean floor by the use of a specially designed radiation detection system. The Health Physics representative provided on-the-job surveillance, served as custodian of radioactive materials as well as assuring that all Federal and State regulations pertaining to the use of radioactive material were followed. The tests were completed without any significant contamination and/or exposure problems.

4.1.13(b) Health Physics Assistance in Radiation Survey Conducted at Lake Ontario Ordnance Works (LOOW) - Radiation and Safety Surveys personnel made two trips to Lewiston, New York, as members of the USAEC Radiological Assistance Team to make a survey of part of the original 1511-acre AEC Lake Ontario Ordnance Works. During the week of October 12-16, 1970, a radiation survey was made of the 213-acre AEC site and of selected off-site locations on the land which formerly comprised the LOOW site. Four members of the Radiation and Safety Surveys Section participated in this survey.

During the period of November 30 through December 11, 1970, two members of the original Radiation and Safety Surveys Section returned for further duties at the site. They were joined by radiation survey personnel from Brookhaven National Laboratory and from National Lead Company of Ohio. The purpose of the second survey was to assist the AEC in determining the extent and level of contamination to a part of the original LOOW property which the AEC had previously sold and to prepare a cost estimate for decontamination proceedings.

4.1.13(c) Health Physics Assistance during Shale Fracturing Test Operations in New York State - Continuous monitoring was provided during two test injections of radioactive tracers in a selected area located in the west portion of New York State. These tests were made to determine the feasibility of shale fracturing in the area as a means of permanent disposal of radioactive liquid waste. Approximately 10 Ci of Zr - Nb were used for each injection. No significant personnel contamination problems resulted and all personnel exposures were kept well below maximum permissible levels.

4.1.13(d) Removal, Transportation, and Disposal of Contaminated Metals from White Wing Scrap Yard - Continuous monitoring was provided for several weeks during the removal of contaminated metals from the White Wing Scrap Yard. This has been a storage area for contaminated metals for several years and was cleaned up at the request of AEC-ORO. The work was done under contract between AEC-ORO and David Witherspoon, Inc., a scrap metal processing company. With the exception of some minor cleanup of the ground yet to be done, all contaminated materials have been removed and disposed of at the ORNL Solid Waste Disposal Area. There were no significant personnel exposures or contamination problems during the work.

4.1.13(e) Removal, Transportation, and Disposal of Radioactive Wastes from American Nuclear Corporation - Continuous monitoring was provided during the loading, transport, and disposal of 84 drums of radioactive wastes from American Nuclear Corporation. The ^{60}Co wastes were removed under contract between ORNL and ANC. The material was transported to the ORNL burial site for disposal. Although the drums measured up to 100 r/hr at 18", the work was completed with all personnel exposures being kept below 100 mrem/week. This was possible by utilizing remote handling equipment, adequate shielding, and planned procedures for the job.

4.2 Unusual Occurrences

Radiation incidents are classified according to a severity index system developed over the past several years.[5] The method serves to index unusual occurrences according to degree of severity and permits a system of analysis regarding Applied Health Physics and Safety practices among Laboratory operations.

During 1970 there were nine unusual occurrences recorded which represents a decrease of 25 percent over the number reported for 1969 (Table 4.2.1). The number for 1970, nine, is approximately 40 percent below the five-year average of 15 for the years 1966 through 1970. The frequency rate of unusual occurrences among Laboratory divisions involved (Table 4.2.2) is known to vary in relationship to the quantity of radioactive material handled, the number of radiation workers involved, and the radiation potential associated with a particular operation or facility.

Five of the incidents reported during 1970 involved area contamination that was handled by the regular work staff without appreciable production or program loss. One incident involved the partial shutdown of a facility with several man-hours of effort expended in the cleanup operation. One occurrence involved personnel contamination requiring decontamination under medical supervision. One involved a reportable exposure with work restrictions imposed.

[5] See ORNL-3665, Applied Health Physics Annual Report for 1968, pp. 14-15.

4.3 Laundry Monitoring

There were approximately 650,000 articles of wearing apparel monitored at the laundry during 1970. Approximately six percent were found contaminated. Of 313,156 khaki garments monitored during the year, 167 were found contaminated. This was about the same percentage as last year.

There were 10,088 full-face respirators cleaned and monitored during the year. Of this number, 622 required additional decontamination measures prior to being placed back in service. Also, 9,084 respirator canisters were cleaned and monitored.

Table 4.2.1 Unusual Occurrences Summarized for the 5-Year Period Ending with 1970

	1966	1967	1968	1969	1970
Number of Unusual Occurrences Recorded	22	16	20	12	9
A. Number of incidents of minor consequence involving personnel exposure below MPE limits and requiring little or no cleanup effort	8	5	7	4	2
B. Number of incidents involving personnel exposure above MPE limits and/or resulting in special cleanup effort as the result of contamination	14	11	13	8	7
1. Personnel Exposures	8	5	9	6	1
a. Nonreportable overexposures with minor work restrictions imposed	8	5	9	6	1
b. Reportable overexposures with work restrictions imposed	0	0	0	0	1
2. Contamination of Work Area	14	11	13	8	6
a. Contamination that could be handled by the regular work staff with no appreciable departmental loss	12	11	13	7	5
b. Required interdepartmental assistance with minor departmental program loss ...	2	0	0	1	1
c. Resulted in halting or temporarily deterring parts of the Laboratory program ..	0	0	0	0	0

Table 4.2.2 Unusual Occurrence Frequency Rate within the Divisions for the 5-Year Period Ending with 1970

Division	No. of Unusual Occurrences 1966	1967	1968	1969	1970	5-Year Total	Percent Lab. Total (5-Year Period)
Analytical Chemistry	1	3	4	1		9	11.4
Biology			1			1	1.3
Chemical Technology	3	4	5	4	2	18	23.7
Inspection Engineering					1	1	1.3
Plant and Equipment	2		1			3	3.9
Electronuclear Research	1					1	1.3
Isotopes	8	4	6	2	3	23	29.1
Metals and Ceramics		1	1	1	1	4	5.1
Neutron Physics			2			2	2.5
Operations	4			2	2	8	10.0
Physics	1	1				2	2.5
Reactor	2	3		1		6	7.6
Solid State				1		1	1.3
TOTALS	22	16	20	12	9	79	100.0

5.0 SAFETY ENGINEERING AND SPECIAL PROJECTS

The safety record for 1970 was very good. There was a decrease in the total number of injuries as compared to 1969. There has been only one year (1969) since the inception of Union Carbide as the contractor at ORNL (1948) in which there were fewer Serious Injuries than the 49 reported in 1970. There have been only six years since 1948 in which the number of Disabling Injuries was less than the five reported in 1970. Thus, ORNL's safety record for the year, while not quite as good in some areas as the record for 1969, continues to be a very commendable one.

5.1 Accident Analyses

The Disabling Injury Frequency Rate for 1970 was 0.76. The average frequency rate for the last ten years, 1961–1970, was 1.03. The Disabling Injury history of ORNL for the six-year period 1965 through 1970 is shown in Table 5.1.1. The Disabling Injury frequency rates since the inception of Union Carbide as the contractor at ORNL (1948) are shown in Table 5.1.2. The average Disabling Injury frequency rate for this period, 1948–1970, was 1.13.

There were 10 divisions which did not have a Serious or Disabling Injury during 1970. There are 17 divisions which have accumulated 1,000,000 or more hours since the last Disabling Injury. The Serious Injury, Disabling Injury, and exposure-hour data for ORNL divisions are shown in Table 5.1.3.

Table 5.1.4 includes injury data for ORNL, Paducah, Y-12, and ORGDP for 1970. In order of decreasing frequency rates, ORNL was number one for Serious Injuries, but number three for Disabling Injuries.

Total injuries at ORNL (including First Aid, Serious and Disabling) dropped from 1,175 in 1969 to 967 in 1970. Tables 5.1.5, 5.1.6, and 5.1.7 show injury data according to type of accident, nature of injury and part of body injured for 1970 injuries.

5.2 Summary of Disabling Injuries

Following are brief summaries of the five Disabling Injuries experienced at ORNL in 1970:

Date of Injury – 4/13/70

An ironworker used a closed 6' stepladder as a straight ladder. While he was climbing, the base slipped out, and he fell about 4' to the floor. His right ankle was fractured. Time loss: 209 days.

Date of Injury - 9/8/70

While ripping a 2" strip from a piece of 3/4" plywood, a carpenter struck his left index finger against the 10" table saw blade. The blade guard was not in place. A small portion of the tuft of the end joint was removed. No time was lost. Time charge: 100 days.

Date of Injury - 9/23/70

A reactor operator was proceeding toward the exit gate after work. Rain suddenly began, and he started to run. He slipped and fell, sustaining an acute strain of the low back. Time loss: 4 days.

Date of Injury - 10/28/70

A painter leaned a 20' straight, aluminum ladder against the eave of a building and started climbing, holding a paint buck in his hand. The ladder was leaning too much to be stable and was not secured. As he reached the upper point of support, the base kicked out and he fell to the concrete pad, fracturing his right ankle. Time loss: 69 days.

Date of Injury - 10/29/70

A pipefitter and a co-worker were lifting a vacuum pump (50 lbs.) from a dolly to place it on a truck bed. The dolly casters dropped off the loading dock. The pipefitter's right middle finger was caught between the pump and the truck bed, partially severing the extensor tendon. Surgery was required in January, 1971, to correct the fault. Time loss: 28 days (estimated).

5.3 Safety Awards

A new Safety Incentive Plan was instituted on January 1, 1969, which added Serious Injuries as a factor in award calculation. This and a separation of employees into groups with their award values depending partly on the group's performance gave a more local and personal accent to safety achievement.

a. Installation-Wide Award - When Laboratory employees complete 1,000,000 labor hours without a Disabling Injury, each participant is credited with $1.00.

b. Group Award - When a group works an entire calendar month without a Serious Injury, each member of the group is credited with $0.50. In general, groups consist of individual divisions. Some smaller divisions were combined into single groups when they reported to the same director. Because of its size, Plant and Equipment was subdivided into 22 groups.

Five 1,000,000-hour injury-free periods were achieved. Groups achieved from a low of nine to a high of 12 months without experiencing a Serious Injury. Thus, annual awards varied from \$9.50 to \$11.00 (\$5.00 installation-wide plus from \$4.50 to \$6.00 group). Gift certificates were awarded rather than cash or merchandise. Almart Stores of Knoxville was awarded the bid and furnished certificates with a face value of 25 percent above the earned amount.

Table 5.1.1 Disabling Injury History—ORNL, 1970

	1965	1966	1967	1968	1969	1970
Number of Injuries	18	4	4	1	2	5
Labor Hours (Millions)	7.7	7.8	8.0	7.8	7.5	6.6
Frequency Rate	2.34	0.51	0.50	0.13	0.27	0.76
Days Lost or Charged	2816	231	245	60	67	410
Severity Rate	366	30	31	8	9	63

Table 5.1.2 ORNL Disabling Injury Frequency Rates Since Inception of Carbide Contract Compared with Frequency Rates for NSC,[1] AEC and UCC

Year	ORNL	NSC	AEC	UCC
1948	2.42	11.49	5.25	5.52
1949	1.54	10.14	5.35	4.91
1950	1.56	9.30	4.70	4.57
1951	2.09	9.06	3.75	4.61
1952	1.39	8.40	2.70	4.37
1953	1.43	7.44	3.20	3.61
1954	0.79	7.22	2.75	3.02
1955	0.59	6.96	2.10	2.60
1956	0.55	6.38	2.70	2.27
1957	1.05	6.27	1.95	2.41
1958	1.00	6.17	2.20	2.21
1959	1.44	6.47	2.15	2.16
1960	0.94	6.04	1.80	1.92
1961	1.55	5.99	2.05	2.03
1962	1.45	6.19	2.00	2.28
1963	1.55	6.12	1.60	2.10
1964	1.07	6.45	2.05	2.20
1965	2.34	6.53	1.80	2.40
1966	0.64	6.91	1.75	2.57
1967	0.50	7.22	1.55	2.06
1968	0.13	7.35	1.27	2.24
1969	0.27	8.08	1.52	2.49
1970	0.76			

[1]National Safety Council (NSC), all industries.

Table 5.1.3 Injury Statistics by Division—1970

Division	Medical Treatment Cases	Serious Injuries No.	Serious Injuries Freq.	Disabling Injuries Number	Disabling Injuries Freq.	Disabling Injuries Sev.	Exposure Hours (In Millions)
Analytical Chemistry	16	1	3.97	0			.252
Chemical Technology	36	1	2.35	0			.425
Chemistry	13	2	10.92	0			.183
Director's	4	0	0.00	0			.204
Electronuclear	5	0	0.00	0			.084
Health Physics	18	2	6.23	0			.321
Instr. and Controls	43	2	3.98	0			.502
Mathematics	6	0	0.00	0			.208
Metals and Ceramics	31	2	3.75	0			.534
Neutron Physics	6	4	34.50	0			.116
Physics	2	0	0.00	0			.101
Reactor	6	0	0.00	0			.033
Reactor Chemistry	8	0	0.00	0			.156
Solid State	4	0	0.00	0			.138
General Engineering	11	1	3.31	0			.302
Health	1	1	19.20	0			.053
Isotopes	22	3	12.40	0			.242
Laboratory Protection	11	0	0.00	0			.135
Operations	42	2	5.73	1	2.37	157	.349
Personnel	14	1	5.43	0			.184
Plant and Equipment	646	25	15.42	4	2.47	251	1.620
Technical Information	7	0	0.00	0			.218
Inspection Engineering	4	0	0.00	0			.077
MAN	3	1	19.23	0			.052
Ecological Science	8	1	17.23	0			.058
PLANT TOTAL	967	49	7.47	5	0.76	63	6.555

Table 5.1.4 Four-Plant Tabulation of Injuries—1970

Plant	Labor Hours (Millions)	Disabling				Serious	
		Number of Injuries	Frequency Rate	Days Lost or Charged	Severity Rate	Number of Injuries*	Frequency Rate
ORNL	6.6	5	0.76	410	63	49	7.47
ORGDP	5.0	2	0.39	93	19	47	9.35
Y-12	12.7	3	0.23	179	14	119	9.34
Paducah	2.1	2	0.97	109	53	31	14.99

*Includes the number of Disabling Injuries

Table 5.1.5 Number of Accidents by Types

Type of Accident	Number of Accidents
Struck Against	365
Struck By	268
Slips, Twist	95
Caught In, on, or Between	63
Falls	42
Inhalation, Injection	11
Contact Temp Extremes	12
Electrical	7
Others	104
TOTAL	967

Table 5.1.6 Number of Accidents by Nature of Injury

Nature of Injury	Number of Accidents
Abrasion, Laceration	368
Contusion	168
Strain	138
Conjunctivitis	36
Burns (Temp)	53
Sprain	17
Burn (Chem)	22
Burn (Flash)	1
Fracture, Dislocation	17
Others	132
TOTAL	967

Table 5.1.7 Number of Accidents Relative to Part of Body Injured

Body Area	Percentage	Total Injuries
Eyes	7.3	71
Head	6.7	65
Arms	11.0	107
Shoulder-Chest	5.0	48
Back	9.4	91
Trunk	2.9	28
Hands	11.0	106
Fingers	34.7	335
Legs	8.0	77
Feet	2.6	25
Toes	1.4	140
TOTAL	100.0	967

6.0 INFORMATIONAL ACTIVITIES

6.1 Visitors and Training Groups

During 1970 there were 41 visitors to Applied Health Physics and Safety, as individuals or in groups, for training purposes. Table 6.1.1 is a listing of training groups which consisted of six or more persons.

Table 6.1.1. Training Groups in Applied Health Physics and Safety Facilities during 1970

Facility	Number	Training Period
AEC Fellowship	6	6/22/70 - 7/24/70
University of Tennessee Co-ops (Physics Department)	8	1/1/70 - 12/31/70[a]
ORAU Ten-Weeks HP Course	14	1/12/70 - 3/20/70[b]

[a] Each student participated in two academic quarters (approximately 24 weeks.

[b] Approximately 50 lecture and field training hours were contributed by ORNL personnel during the period noted above.

6.2 Publications and Papers

H. H. Abee, W. D. Cottrell, K. E. Cowser and D. J. Nelson, "Environmental Monitoring Significance of the Clinch River Study", Ch. 42, pp. 388-393, of Proceedings of Health Physics Society Midyear Topical Symposium on Environmental Surveillance in Vicinity of Nuclear Facilities, August, Georgia, January 24-25, 1968, Edited by William C. Reinig, Charles C. Thomas, publisher, Springfield, Illinois, 1970.

T. J. Burnett, "A Derivation of the 'Factor of 700' for ^{131}I", Note Published in Health Physics, Vol. 18, No. 1, pp. 73-75, January, 1970.

D. M. Davis, Applied Health Physics and Safety Annual Report for 1969, ORNL-4563, August, 1970.

D. M. Davis and E. D. Gupton, Health Physics Instrument Manual, ORNL-332 (Revision), February, 1970.

E. D. Gupton, Methods and Procedures for External Radiation Dosimetry at ORNL, January, 1970, ORNL CF 70-1-53, January 1, 1970.

E. D. Gupton, Methods and Procedures for Internal Radiation Dosimetry at ORNL, ORNL CF 70-1-58, January 1, 1970.

E. D. Gupton, "Health Physics Aspects of a Plutonium-Americium Glove Box Explosion", presented at the Southeastern Industrial Health Conference, Gatlinburg, Tennessee, September 30 - October 2, 1970.

E. D. Gupton, et al., Technical Report Series No. 109, "Personnel Dosimetry Systems for External Radiation Exposures", IAEA, Vienna, 1970.

J. C. Hart, "Evaluating the Dose Record Over the Long Term", presented at the Sixteenth Annual Bio-Assay and Analytical Chemistry Conference, Bethesda, Maryland, October 8-9, 1970.

C. E. Haynes, Transuranium Element Health Physics and Safety at Oak Ridge National Laboratory, paper presented at the Seminar on Radiation Protection Problems Relating to Transuranium Elements held at Karlsruhe, Germany, September, 1970.

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